THE APPLICATION OF SKYLAB EREP DATA FOR LAND USE CLASSIFICATION AND MAPPING IN THE CLEVELAND AND COLUMBUS AREAS

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DEMONSTRATION OF THE USE OF SKYLAB PHOTOGRAPHY FOR OHIO LAND USE PLANNING INTERESTS

by

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INTRODUCTION

In March, 1973, the State of Ohio entered into a no-cost Skylab data analysis agreement with the National Aeronautics and Space Administration (NASA) to study the potential state level utility of data acquired by the Skylab Earth Resources Experiment Package (EREP). Under this agreement, NASA has obtained Skylab SL-2, SL-3, and SL-4 photographic coverage of selected areas of Ohio (mainly Cleveland and Columbus) as well as multispectral aircraft underflight data for the two study sites. In turn, the State of Ohio and specifically the Department of Economic and Community Development (DECD) agreed to undertake a preliminary analysis of the potential land use planning value of the Skylab data acquired. This report represents the results obtained by a DECD funded contract to Battelle's Columbus Laboratories for analyzing initial Skylab S 190 A and S 190 B photographic data primarily for the Cleveland, Ohio study site area.

This report describes Ohio Skylab data available, analysis techniques utilized, and results derived from this experimental program. The report is prepared in a demonstration-style format in that its purpose is to demonstrate the land use classification and mapping potential of this new satellite data base to state, regional, and local planners and decision makers. The reader is reminded that several other resource management application possibilities exist for Skylab data which remain to be studied. Also similar data use demonstration products have resulted from Ohio's participation in the first NASA Earth Resources Technology Satellite (ERTS-1) program.

SKYLAB DATA ACQUISITION

A variety of earth observation sensors comprise the Earth Resources Experimental Package (EREP) aboard the Skylab space station. Descriptions of the various multispectral sensing instruments are given in Figure A-1 of the Appendix. The S 190 A and S 190 B EREP data were acquired some 525 km over Ohio only in photographic format, while the remaining EREP data were acquired on magnetic tapes. In addition, various areas of Ohio were randomly photographed by the astronauts using handheld 70-mm Hasselblad and 35-mm Nikon cameras*. Table A-1 of the Appendix correlates the dates of various Skylab EREP sensor data acquisitions of Ohio areas for the SL (Skylab) 2 mission (5/25/73 to 6/22/73) and the SL 3 mission (7/28/73 to 9/25/73). Ohio data acquired during the SL 4 (11/10/73 to 2/8/74) mission have not as yet been made available to investigators.

The general area of Ohio covered and the quality of each S 190 A, S 190 B, 70 MM handheld Hasselblad and 35 MM handheld Nikon photograph acquired during the SL 2, SL 3, and SL 4 missions are noted in Tables A-2 to A-4 of the Appendix. Multispectral aircraft underflight data flown as part of the Skylab program by NASA for the Cleveland and Columbus test sites are included as Table A-5.

In some cases, NASA ERTS-1 imagery, state-flown aircraft photography, and on-site photographic and radiometric (spectral) ground truth data (especially of the Cleveland area) acquired as part of the Ohio ERTS program were used in the analysis of Skylab data. The ground truth data base for Cleveland includes such features as: sand and gravel mining operations; agricultural crops and bare soils; beaches; the waters of the Cuyahoga River and Lake Erie; cement and blacktop streets, and industrial smoke plumes.

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* All Skylab photographic data as well as ERTS-1 and NASA aircraft underflight data acquired have been made part of the public domain and can be purchased at reasonable costs from the U. S. Department of the Interior, EROS Data Center, Sioux Falls, South Dakota 57198. [(605) 399-2270]

SKYLAB DATA ANALYSIS

Analytical Techniques

The analysis of Skylab imagery was performed primarily on opto-electro-mechanical equipment available at Battelle's Remote Sensing Applications Laboratory shown in Figure 1 below. The Skylab data were analyzed using a combination of photographic magnification, multispectral analysis, and density slicing/color enhancement techniques. Although some S 192 multispectral scanner data were received, they were not utilized in this preliminary effort. Particular attention was given to identifying Ohio land use features discernible on Skylab imagery and to determining and demonstrating how Skylab/EREP S 190 A and S 190 B data can be used for regional and local land use planning and mapping using Cleveland as the principal test area.

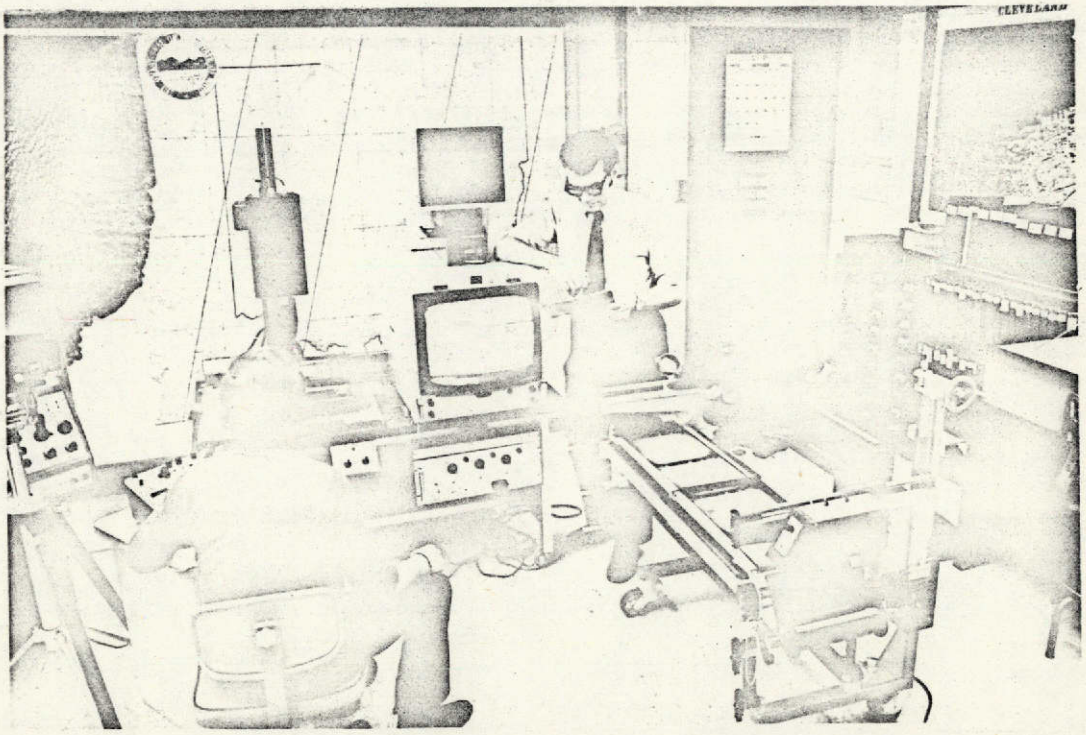

Figure 1. Battelle-Columbus Remote Sensing Applications Laboratory Used in the Analysis of Skylab Photography

Land Use Features Discernible on Skylab/EREP S 190 A and S 190 B Data

The extent to which various Ohio land use features can be discerned on Skylab data relative to the land use classification system proposed by the U. S. Geological Survey for use with remotely sensed data is provided in Table 1. Figure 2 is a black and white photograph of an original S 190 B color IR scene of eastern Ohio of 15 September 73 showing the more prominent natural and cultura surface features.

Additional Ohio surface features discernible are illustrated in Figures to 3f which are color enlargements of original SL-3 S 190 A and S 190 B images. In essence, Ohio surface features identified on Skylab photography vary from lake freighters and suspended sediments in Lake Erie to power towers and corridors in southern Ohio and from surface mining and reclamation activities in eastern Ohio to agricultural lands in western Ohio.

Feature identification and inventory of Ohio's diverse natural and cult surface resources is perhaps the first prerequisite needed to ensure the wise and balanced use of Ohio's land resources. Synoptic data such as that acquired by NASA's Skylab and other earth observation satellite programs, may provide a valuable multiagency data base for the State's ongoing environmental and resource planning activities.

TABLE 1. OHIO LAND USE FEATURES DISCERNIBLE ON S 190 A & S 190 B SKYLAB PHOTOGRAPHY

USGS Land Use Classification System for Use With Remote Sensor Data*			Skylab Analysis Status
Level I	Level II		
01. Urban and Built-Up Land			
	01.	Residential	Yes
	02.	Commercial and Services	Yes
	03.	Industrial	Yes
	04.	Extractive	Yes
	05.	Transportation, Communications, and Utilities	Yes
	06.	Institutional	Yes
	07.	Strip and Clustered Settlement	Yes
	08.	Mixed	Yes
	09.	Open and Other	Yes
02. Agricultural Land			
	01.	Cropland and Pasture	Yes
	02.	Orchards, Groves, Bush Fruits, Vineyards, and Horticultural Areas	No
	03.	Feeding Operations	No
	04.	Other	
03. Rangeland			
	01.	Grass	N/A**
	02.	Savannas (Palmetto Prairies)	N/A
	03.	Chaparral	N/A
	04.	Desert Shrub	N/A
04. Forest Land			
	01.	Deciduous	Yes
	02.	Evergreen (Coniferous and Other)	Yes
	03.	Mixed	Yes
05. Water			
	01.	Streams and Waterways	Yes
	02.	Lakes	Yes
	03.	Reservoirs	Yes
	04.	Bays and Estuaries	Yes
	05.	Other (Ice and Snow)	Yes
06. Nonforested Wetland			
	01.	Vegetated	Yes
	02.	Bare	Yes
07. Barren Land			
	01.	Salt Flats	N/A
	02.	Beaches	Yes
	03.	Sand Other Than Beaches	N/A
	04.	Bare Exposed Rock	Yes
	05.	Other	
08. Tundra			
	01.	Tundra	N/A
09. Permanent Snow and Icefields	01.	Permanent Snow and Icefields	N/A

* "A Land Use Classification System for Use With Remote Sensor Data", J. R. Anderson, E. E. Hardy, and J. T. Roach, U. S. Geological Survey Circular 671, Wash., D. C., 1972.

** N/A = Classification not applicable to Ohio.

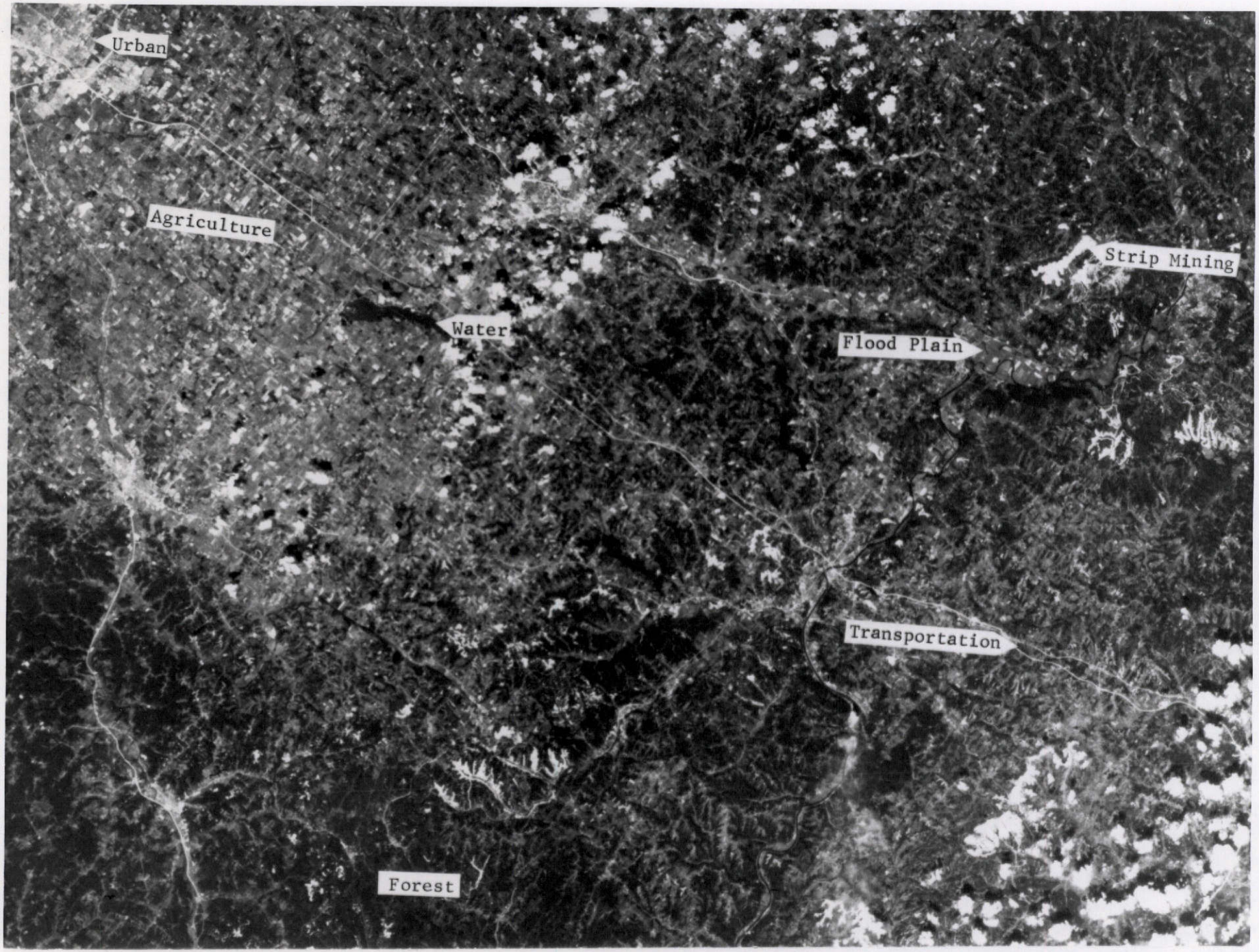

Figure 2. Ohio Natural and Cultural Surface Features Discernible on Skylab S 190 B Photography

This Skylab photo shows a portion of east-central Ohio from Columbus in the upper left, past Buckeye Lake on Interstate 70 east and through Zanesville in the lower right. On the left are Lancaster and Logan.

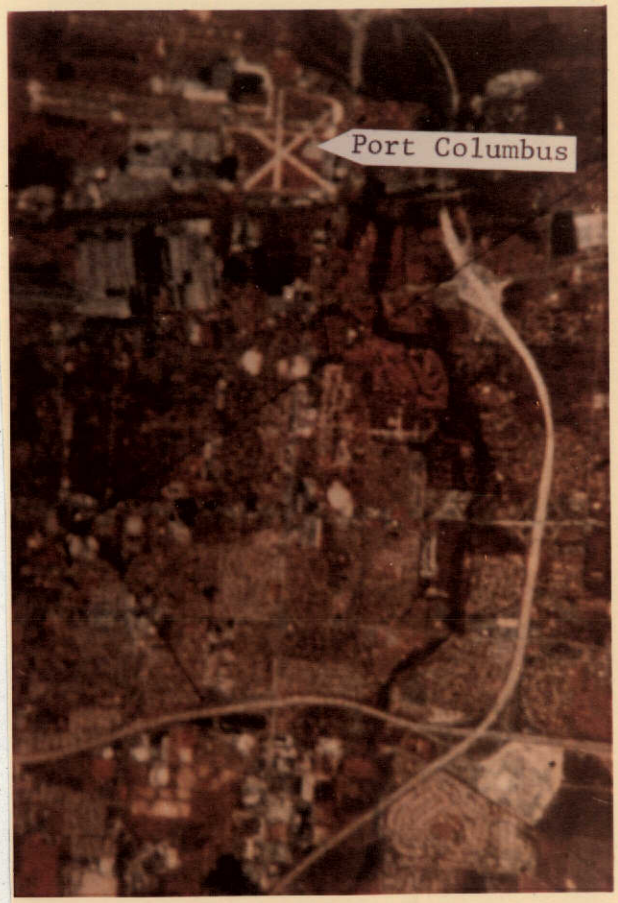

Figure 3a. Enlargement of Skylab S 190 B Color IR Photograph of 15 Sept 73 Showing a Portion of the Eastern Edge of Columbus.

Port Columbus airport is at the top of the photograph and Interstates 270 and 70 run from top to bottom and from left to right respectively. Various urban land uses are readily distinguishable.

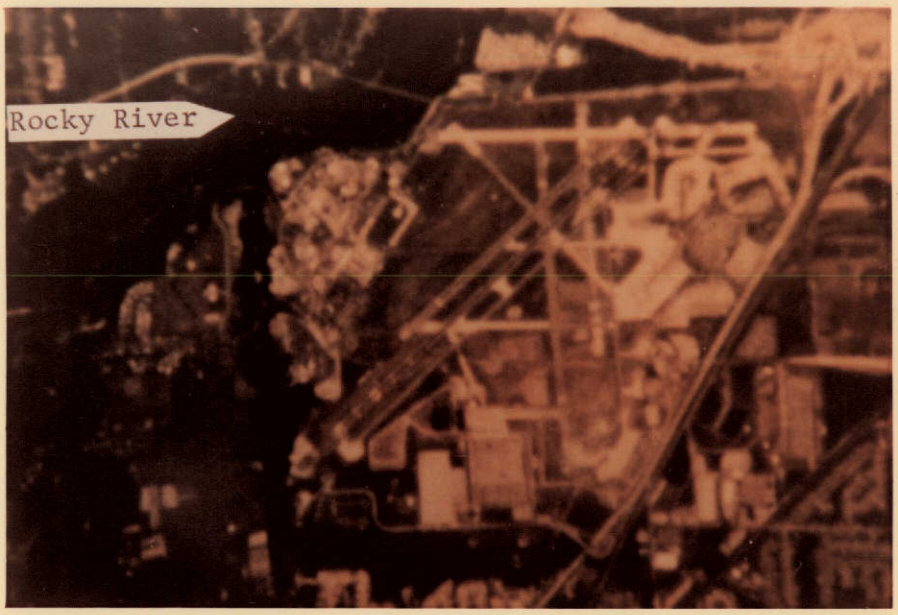

Figure 3b. Enlargement of Skylab S 190 B H.R. Color Photograph of 5 Aug 73.

Cleveland-Hopkins International Airport is to the right of the picture and the Rocky River Valley is shown in the darker tones to the left of the picture.

Figure 3c. Enlargement of Skylab S 190 B Color IR Photograph of 15 Sept 73 Showing a Portion of the Scioto River Flood Plain.

Differences in Agricultural Crops are Noticeable.

Figure 3d. Enlargement of Skylab S 190 B Color IR Photograph of 15 Sept 73 of Southern Ohio

Various vegetation categories are easily recognized. The darker red areas in the upper right of the frame are mature forested areas, the medium red areas in the lower right are brushy areas and the lighter toned areas in the lower left are agricultural fields. A power corridor and power towers are also noticeable extending from the top to the bottom in the middle of the frame.

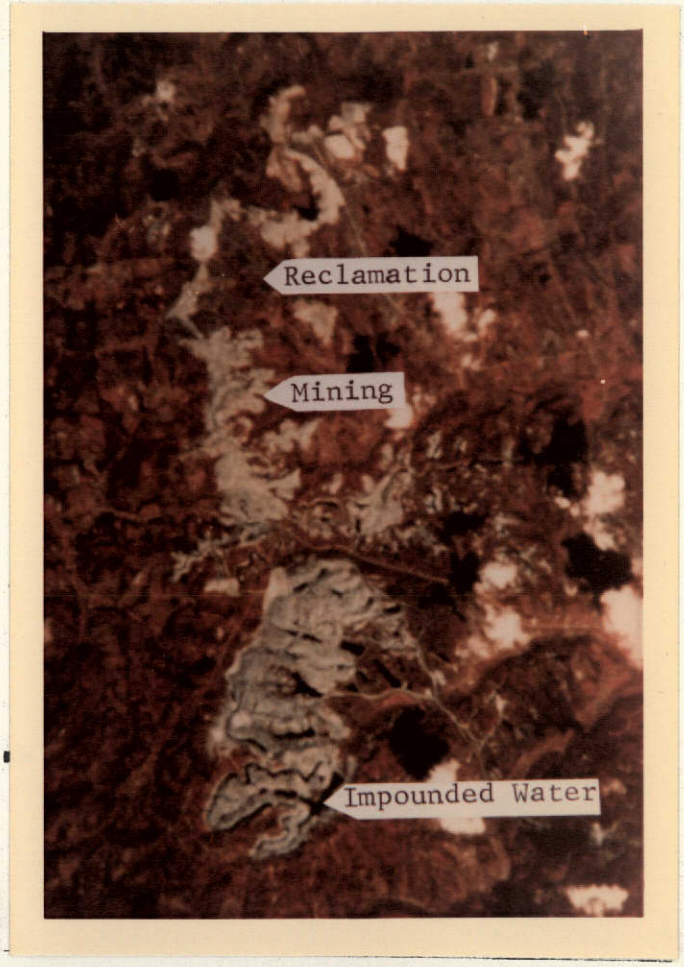

Figure 3e. Enlargement of Skylab Color S 190 B I.R. Color Photograph of Eastern Ohio Showing Coal Surface Mining and Reclamation Activities as Well as Impounded Water Bodies.

Figure 3f. Enlargement of Skylab S 190 A H.R. Color Photograph of 9 Aug 73 Showing the 7-1/2 Mile Oval Track of the Ohio Transportation Research Center Near East Liberty, Ohio and the Surrounding Area.

Land Use Mapping From Skylab High Resolution (H.R.) Color Photography

One land use study of the Cleveland area involved the analysis of a photographic enlargement of the S 190 B H.R. Color photograph of 5 August 73 of northeastern Ohio shown in Figure 4 (natural color) and Figure 5 (black and white). The scale of the original photograph was ~ 1:1,000,000; the enlargements are ~ 1:250,000.

These photographic enlargements were used to produce the USGS Level I and Level II land use classification maps at 1:250,000 scale for the Cleveland/ Cuyahoga County area shown in Figure 6. Using standard planimetric techniques, areas of the various Level I land use categories shown in Figure 6 were calculated and results are shown below:

• Urban	89,350 hectares	(220,836 acres)
• Forestry	48,426 hectares	(119,687 acres)
• Lake Erie	80,221 hectares	(198,272 acres)
• Open Areas	59,245 hectares	(146,429 acres)
• Agriculture	14,070 hectares	(34,776 acres)
Total Area	291,312 hectares	(720,000 acres)

For comparison purposes, a section of the urban area shown in Figure 6 was enlarged to a scale of 1:48,000 (Figure 7) and compared to a mosaic of aircraft photography at the same scale (Figure 8). Selected feature identification and classification of the Skylab sampled area was estimated to be over 90 percent accurate.

Figure 4. Color Enlargement of a Portion of Skylab S 190 B High Resolution Color Photograph of 5 Aug 73 of the Cleveland Area

Scale ~ 1:250,000.

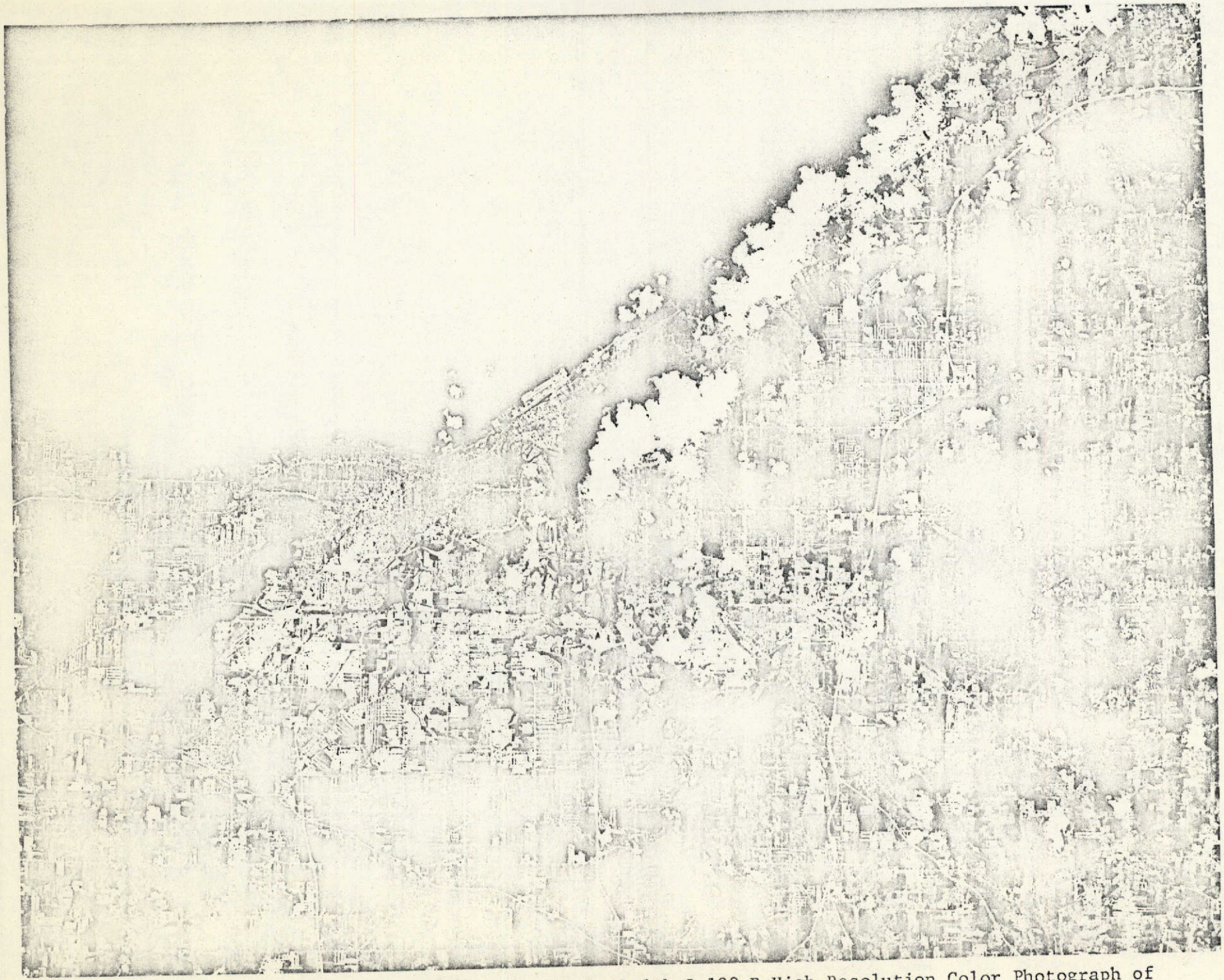

Figure 5. B&W Enlargement of a Portion of Skylab S 190 B High Resolution Color Photograph of 5 Aug 73 of the Cleveland Area

Scale ~ 1:250,000.

Level I Land Uses in Cleveland and Surrounding Area. Skylab S-190B Photo. August 1973.

LEVEL II

Figure 6. Land Use Classifications of Cleveland/Cuyahoga County Derived From Skylab S 190 B Photograph of 5 Aug 73.

Figure 7. Enlarged Portion of a Skylab Photograph of an Urbanized Area in Cleveland on 5 Aug 73

Scale 1:48,000.

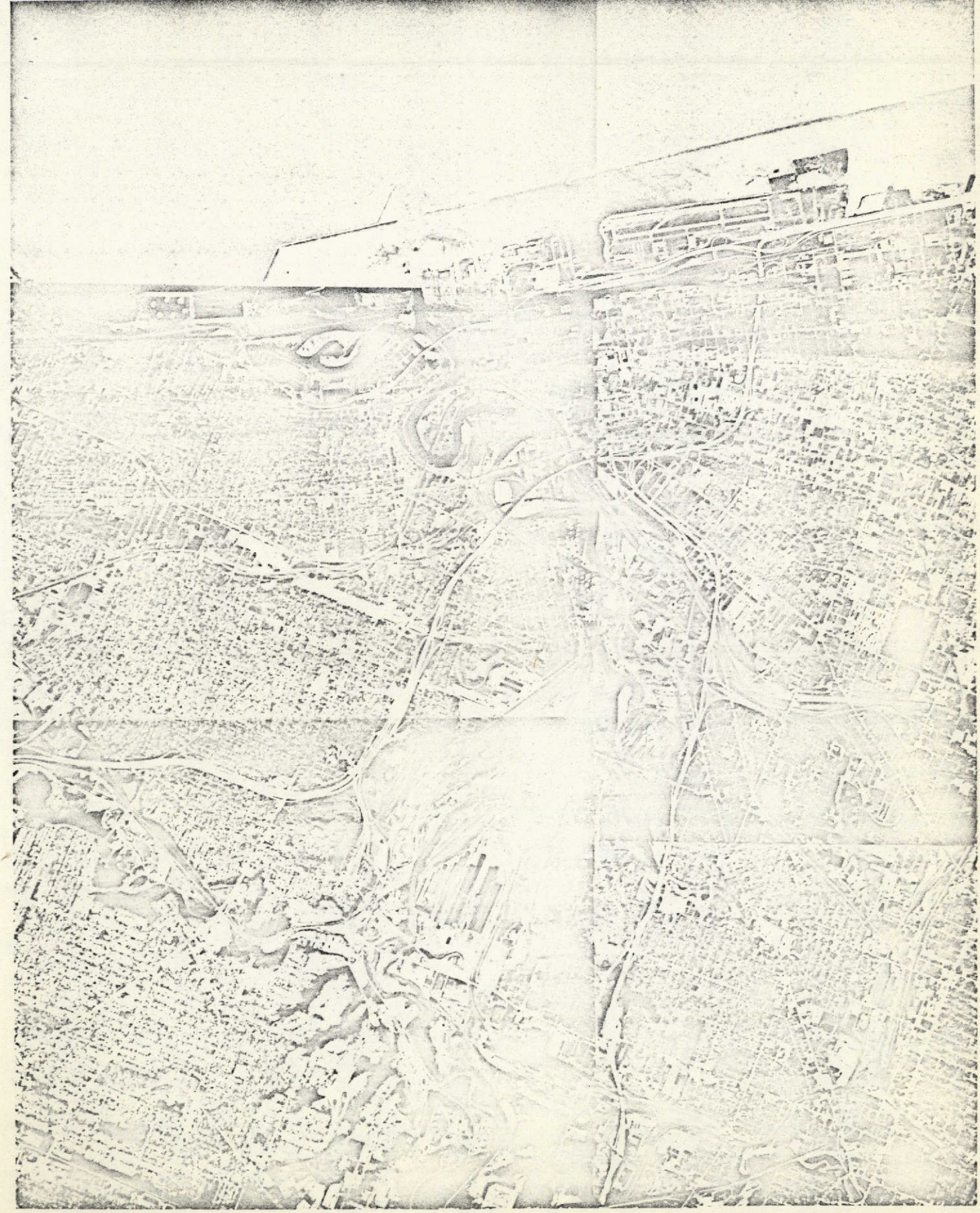

Figure 8. Aerial Photography Mosaic of a Selected Portion of Cleveland Taken on 14 June 73 Used for Skylab Data Comparisons and Feature Verification

Scale ~ 1:48,000.

Land Use Mapping From Skylab Multispectral Imagery

This investigation involved basically the analysis of individual and combined bands from S 190 A data*. A complete Skylab scene for the northeastern portion of Ohio covering ~ 26,500 sq km was used to demonstrate the State/regional land use mapping capability of the Skylab data, see Figure 9. That individual land use features are more readily distinguishable in different portions of the electromagnetic spectrum is illustrated by comparison of the B&W visible and the Infrared photographs shown in Figures 9a and 9b.

By combining the two photographs shown in Figures 9a and 9b a false color composite (shown in Figure 10) was produced through filter enhancement in which different natural and cultural features are highlighted. Using density slicing and color enhancement analysis techniques, thematic display products are potentially useful for showing single and/or interrelated views of natural and cultural features at various scales can be provided. Such a thematic display of the Cleveland/Akron region is shown in Figure 11. Similar thematic displays can be produced in transparency overlay form also for accurate comparison with existing maps (especially topographical maps) required for map revision and for trend analysis.

Multispectral photography such as S 190 A data is very valuable for feature identification. Every object, living or inanimate absorbs or reflects light in a highly characteristic way and thus has a unique "signature" in the realm of multispectral light. By utilizing such spectral signatures and the geometric or spatial characteristics of such features, the various natural and cultural earth surface features can be identified from Skylab and other remotely sensed data.

In S 190 A multispectral photographs, cultural features such as urbanized areas are more prominent on 5,000-6,000 A photographs, vegetation differences on 6,000-7,000 A and 7,000-8,000 A photographs, and water bodies on 8,000-9,000 A infrared photographs. The broad band high resolution (H.R.) color (4,000-7,000 A) and infrared (IR) color (5,000-8,800 A) photographs provide additional information particularly the color renditions which aid in discerning various Ohio features.

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* See Table A-1 in the Appendix.

Skylab PANX B&W (5,000-6,000 A) Photograph in Which Urban Areas and Other Cultural Features Such as Transportation Networks Appear as Lighter, Grey-Tone Features

Skylab B&W Infrared (7,000-8,000 A) Photograph in Which Urban Areas and Water Bodies Appear as Extremely Dark Features

Figure 9. S 190 A Visible and Infrared Multispectral Photographs of Northeastern Ohio Taken by the SL-3 Astronauts on 5 Aug 73. Area covered is 163 x 163 km.

Figure 10. False Color Composite Made by Combining the S 190 A Bands Shown in Figure 9

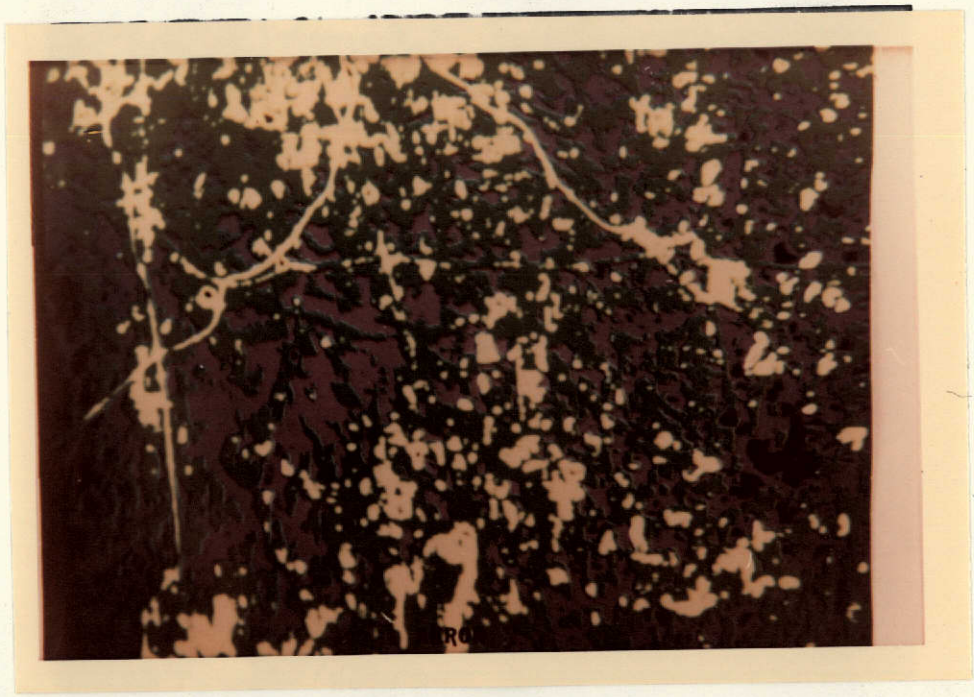

Figure 11. Color Enhanced Thematic Display Showing Various Land Uses in the Cleveland/Akron Region

Urban and transportation features are represented by yellow, open spaces by green, forests by purple and water bodies by black.

OTHER PROGRAM ACTIVITIES

In combination with similar ongoing ERTS activities, some effort was expended on organizing and conducting a joint Department of Economic and Community Development and Battelle's Columbus Laboratories Ohio ERTS/Skylab Data User Workshop held on March 4-5, 1974. The principal purpose of this two-day workshop was to present the significant application findings of the Ohio ERTS and Skylab programsto date and to solicit user views as to the potential utility of satellite survey data to land use, resource management, and environmental quality problem areas at the local, regional, and state levels in Ohio. Over 100 persons attended various sessions of the two-day workshop (see Figure 12). In addition to the Workshop, numerous personnel from various governmental agencies tourned the Remote Sensing Applications Laboratory at Battelle during the course of this program.

On April 19, 1974, a joint State of Ohio - Battelle's Columbus Laboratories paper entitled "Multidisciplinary Applications of ERTS and Skylab Data in Ohio", was presented at the Ninth International Symposium on Remote Sensing of Environment held in Ann Arbor, Michigan.

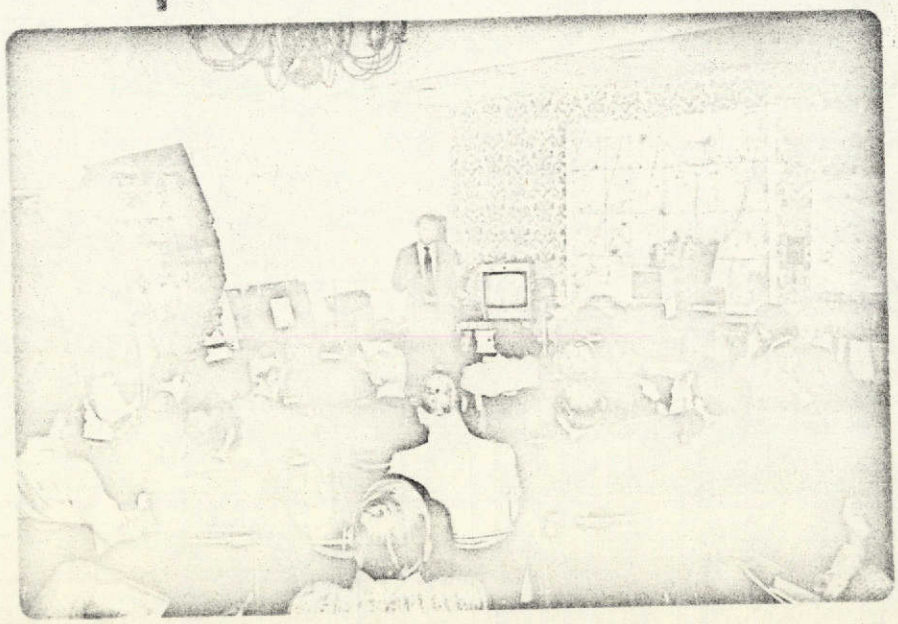

Figure 12. Pictures and Displays at the Ohio ERTS/Skylab Data Users Workshop, Stouffer's University Inn, Columbus, Ohio, March 4-5, 1974

RESULTS/SUMMARY

Throughout the Ohio Skylab program attention has been given to assessing the usefulness and relevance of satellite data to Ohio land use programs and interests, satellite survey data analysis techniques that can be utilized, and products that can be produced for general land use planning applications. Initial evaluation of representative Ohio Skylab photographs indicates that the data are more than adequate for mapping and inventorying major natural and cultural surface features at scales of 1:24,000 and smaller.

The major future operational significance of such manned orbital survey data is that a current, comprehensive, and synoptic view of Ohio's many diverse environmental, natural, and cultural surface features and their interrelationships can be made available to fulfill increasing land use data requirements. In addition to detecting, inventorying, mapping, and monitoring natural and cultural surface features at state, regional, and local scales, Skylab type data could be useful in an operational mode for planning and monitoring specialized developments and activities such as nuclear power facilities; transportation facilities; reservoirs, parks, and recreational facilities; prime agricultural lands and areas of environmental concern; urban growth and developments; and extractive industries such as surface mining.

Although no machine processing of digital data was undertaken in the initial Skylab effort, experience in the Ohio ERTS program and that of other investigators has shown that the degree of feature detail that can be extracted by computerized multiband processing of satellite digital data is even better than that extractable from photographic data by magnification and electronic enhancement techniques.

However, more detailed and additional photographic (especially multispectral) and computerized discipline data analysis efforts are required to evaluate and utilize this unique data base. Accordingly, additional Skylab data analysis opportunities are being formulated with respect to agricultural, surface mining, and land use interests.

A secondary but highly significant finding of this initial Skylab data analysis is that the 10-30 meter resolution associated with the Skylab photographic systems appears to be very responsive to state, regional, and local land use planning data needs. Accordingly to be of maximum benefit, serious NASA considerations should be given to upgrading the spatial capacity of future earth resource orbital in surveys system to approach that of Skylab capabilities, at least for selected areas and selected times.

APPENDIX

SKYLAB SENSOR CHARACTERISTICS AND DATA

SENSOR	DESCRIPTION	SPECTRAL COVERAGE	SPECTRAL RESOLUTION	GROUND COVERAGE	SPATIAL RESOLUTION
S-190(A) MULTISPECTRAL PHOTOGRAPHIC CAMERA	SIX 70mm CAMERA MATCHED DISTORTION AND FOCAL LENGTH (15.2cm) 12 METERS REGISTRATION 18 FILTERS 21° FOV	MICROMETERS .5 - .6 PANX B&W .6 - .7 PANX B&W .7 - .8 IR B&W .8 - .9 IR B&W .5 - .88 IR COLOR .4 - .7 HR COLOR	0.1 MICROMETERS	163 x 163 Km	APPROX. 24m TO 68m *
S-190(B) EARTH TERRAIN CAMERA	460 mm FOCAL LENGTH 114mm FILM FORMAT 3 FILTERS	0.4 TO 0.7 H. R. AERIAL COLOR 0.5 TO 0.88 IR COLOR 0.5 TO 0.7 HIGH DEFINITION AERIAL B & W	0.1 MICROMETERS	109 X 109 Km	APPROX. 10m TO 38m *
S-191 INFRARED SPECTROMETER	POINTED BY CREW FILTER WHEEL ONE SEC. SCAN RATE ONE mRAD FOV CRYOGENIC COOLER 16mm CAMERA	0.4 TO 2.4 AND 6.2 TO 15.5 MICROMETER	1% TO 4%	0-45° FWD 0-20° SIDE 0-10° REAR	0.44 Km SPOT
S-192 MULTISPECTRAL SCANNER	IMAGE PLANE SCANNER 6000RPM SCAN MIRROR CRYOGENIC COOLER HgCdTe DETECTORS (13 USED) 0.186 mRAD FOV	0.4 TO 2.35 AND 10.2 TO 12.5 MICROMETERS	13 BANDS: 0.04 TO 0.1 MICROMETERS	68 Km SWATH	80 x 80 m SPOT
S-193 MICROWAVE RADIOMETER/SCATTEROMETER AND ALTIMETER	1.1m PARABOLIC ANTENNA TWO AXIS GIMBAL (0-48° IN FIVE STEPS) 1.5° FOV DUAL POLARIZATION ALTIMETER NADIR SEEKER	13.8 TO 14.0 GHz (13.9 GHz CENTER FREQUENCY)	SCAT RECEIVER: FIRST IF: 500 MHz SECOND IF: 50 MHz RAD RECEIVER: SINGLE FREQUENCY	0-48 FWD 0-48 SIDE	11 x 11 Km SPOT
S-194 L-BAND RADIOMETER	1 m PHASED ARRAY (8 x 8 ELEMENTS) COLD AND HOT REF.	1.400 TO 1.427 GHz	18 MHz FROM CENTER FREQUENCY	111 Km CIRCLE	111 Km SPOT

NOTES: FOV = FIELD OF VIEW
* - DOES NOT INCLUDE LOSS DUE TO ATMOSPHERE EFFECTS OR FILM PROCESSING.

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REV. 2-10-73

Figure A-1. Skylab EREP Sensor Characteristics

From Skylab Earth Resources Investigations, National Aeronautics and Space Administration, February 1973.

TABLE A-1

SKYLAB COVERAGE AND DATA RECEIVED OF OHIO AREAS

SL2 (12 June 73)	
(EREP Pass 9 Track No. 61)	
S 190A*	Detroit-Cleveland-Pittsburgh
S 191	Cleveland to Pittsburgh
S 192*	Detroit-Cleveland-Pittsburgh
S 193	Detroit-Akron
S 194	Detroit-Cleveland-Pittsburgh
SL3 (5 Aug 73)	
(EREP Pass 3 Track No. 61)	
S 190A*	Detroit-Cleveland-Pittsburgh
S 190B*	Detroit-Cleveland-Pittsburgh
S 191	Cleveland-Pittsburgh
S 193	Detroit-Akron
S 194	Detroit-Cleveland-Pittsburgh
SL3 (9 Aug 73)	
(EREP Pass 6 Track No. 47)	
S 190A*	Fort Wayne-Columbus-Marietta
S 192	Fort Wayne-Columbus-Marietta
S 193	Fort Wayne to Lima
S 194	Fort Wayne-Columbus-Marietta
SL3 (14 Sept 73)	
(EREP Pass 29 Track 1/2)	
S 190A	Kokomo to Toledo
S 193	Fort Wayne to Toledo
S 194	Fort Wayne to Toledo
SL3 (15 Sept 73)	
(EREP Pass 31 Track 15/16)	
S 190A*	Georgetown to Steubenville
S 190B*	Georgetown to Steubenville
S 191	Georgetown to Steubenville
S 194	Georgetown to Steubenville
SL3	
(EREP Pass 19 Track No 15)	
S 190B	New Philadelphia to Youngstown
S 191	Washington Court House-Cols.-Youngstown
S 193	Cincinnati to Youngstown
S 194	Cincinnati to Youngstown
(EREP Pass 18 Track No. 1)	
S 191	Kokomo to Toledo
S 192	Fort Wayne to Toledo
S 194	Fort Wayne to Toledo

* Data received to date.

TABLE A-2

COVERAGE AND QUALITY OF SKYLAB S 190 A PHOTOGRAPHY OF OHIO

Date	Frame	Area	Quality Comments*
6/12/73	152	Eastern Michigan, Detroit, Lake St. Clair, Western Lake Erie	Fair
6/12/73	153	Detroit, Toledo, Sandusky Bay, Western Lake Erie	Fair
6/12/73	154	Toledo to east of Cleveland	Fair
6/12/73	155	Sandusky Bay to Erie, Pa.	Fair
6/12/73	156	Cleveland area	Fair
6/12/73	157	Eastern Central Pennsylvania	Poor
8/5/73	185	Eastern Michigan, Detroit, Lake St. Clair, Western Lake Erie	Very Good
8/5/73	186	Detroit, Toledo, Sandusky Bay, Western Lake Erie	Excellent
8/5/73	187	Sandusky Bay to Erie, Pa.	Excellent
8/5/73	188	Cleveland and Northeastern Ohio	Excellent
8/5/73	189	Eastern Ohio, Western Pennsylvania	Excellent
8/5/73	190	Eastern Ohio, Western Pennsylvania, Pittsburgh	Excellent
8/9/73	017	Northern Indiana, Southern Michigan, and Western Ohio	Good
8/9/73	018	Western Ohio	Good
8/9/73	019	Central Ohio	Fair
8/9/73	020	Eastern Ohio	Fair
8/9/73	021	Eastern Ohio, Western Pennsylvania, and West Virginia	Good
8/9/73	022	Eastern Ohio, Western Pennsylvania, and West Virginia	Excellent
8/9/73	023	West Virginia	Good
8/9/73	024	West Virginia, Virginia	Fair
9/15/73	307	Indiana/Kentucky	Good
9/15/73	308	Central Kentucky/Indiana	Very Good
9/15/73	309	Southwestern Ohio	Very Good
9/15/73	310	Columbus & Southeastern Ohio	Fair
9/15/73	311	Eastern Ohio/Western Pennsylvania	Fair
9/15/73	312	Western Pennsylvania	Fair
11/25/74	013	Michigan, Indiana, and NW Ohio	Excellent
11/25/74	014	Indiana, and NW Ohio	Excellent
11/25/74	015	Western Ohio	Very Good
11/25/74	016	Western and Central Ohio	Good
11/25/74	017	Central Ohio	Good
11/25/74	018	Eastern Ohio	Good
11/25/74	019	Southeastern Ohio/West Virginia	Good
11/25/74	020	Southeastern Ohio/West Virginia	Fair

* Quality relates to general cloud cover condition over area covered by satellite photography.

TABLE A-3

COVERAGE AND QUALITY OF SKYLAB S 190 B PHOTOGRAPHY OF OHIO

Date	Type	Frame	Area	Quality Comments*
8/5/73	H.R. Color	SL3-83-153	Lake St. Clair & Ontario, Canada	Excellent
8/5/73	H.R. Color	SL3-83-154	Cleveland, Lake Erie, and Canada	Excellent
8/5/73	H.R. Color	SL3-83-155	Cleveland	Excellent
8/5/73	H.R. Color	SL3-83-156	Cleveland & NE Ohio	Excellent
8/5/73	H.R. Color	SL3-83-157	NE Ohio & Western Pennsylvania	Excellent
8/5/73	H.R. Color	SL3-83-158	Eastern Ohio, West Virginia, and Western Pennsylvania	Excellent
9/15/73	IR Color	SL3-87-052	Kentucky/SW Ohio	Excellent
9/15/73	IR Color	SL3-87-053	Columbus & Southern Ohio	Excellent
9/15/73	IR Color	SL3-87-054	Columbus & Southeastern Ohio	Good
9/15/73	IR Color	SL3-87-055	Eastern Ohio	Poor
9/15/73	IR Color	SL3-87-056	Eastern Ohio/Western Pa.	Poor

* Quality relates to general cloud cover condition over area covered by satellite photography.

TABLE A-4

SKYLAB HANDHELD PHOTOGRAPHIC IDENTIFICATION LIST

NASA Frame Number	Area Covered
70 MM HANDHELD HASSELBLAD CAMERA	
SL2-5-390	Michigan, Ohio, Ontario, Lake Erie
SL2-5-391	Lake Erie, Ontario, New York, Lake Ontario
SL2-6-516	Michigan/Ohio, Lake Erie, Toledo, Sandusky
SL2-6-517	NE Ohio, Lake Erie, Ontario, Cleveland
SL2-6-518	All of Ohio Except Cincinnati
SL2-6-521	Ohio, Pa., Va., W.Va., Allegheny Mt.
SL2-6-559	Ohio, Inc., Michigan, Ontario, Lake Erie
SL2-6-569	Ohio, Pa., N. Y., Lake Erie
SL3-114-1643	Skylab at Rendezvous - Ohio, Ky.
SL3-114-1703	Michigan, Ohio, Ontario
SL3-116-1947	Detroit, Lake Erie, Ohio
SL3-116-1948	Detroit, Lakes Erie, Huron, and Ontario
SL3-116-1951	Lake Erie, Ohio-Ontario
SL3-116-1991	Ohio, Indiana, and Ky.
SL3-116-2026	Ontario, Ohio, Michigan, Lake Erie
SL3-121-2408	Canada, Lake Erie, Ontario, Ohio
SL3-121-2423	Ohio, Penn., Ontario, Lake Erie
35 MM HANDHELD NIKON CAMERA	
SL2-103-958	Detroit, Lake Erie, Ohio, New York
SL2-103-992	Southern Ohio, Kentucky, Indiana
SL2-104-1052	Michigan, Lake Erie, Ohio, Ontario
SL2-104-1053	Cleveland, Lake Erie
SL2-104-1054	Ashtabula, Lake Erie
SL2-104-1055	Sandusky, Lake Erie
SL2-106-1152	Sandusky, Ohio (out of focus)
SL2-106-1153	Toledo, Ohio (out of focus)
SL3-124-2723	Ohio, Scioto River
SL3-128-2996	Lake Erie, Buffalo, Niagara Falls
SL3-119-2207	Cincinnati, Ohio
SL3-119-2208	Sandusky, Ohio
SL3-119-2219	Canton, Ohio
SL3-125-2806	Fort Wayne, Indiana, Ohio
SL3-118-2142	Lake Erie, Ohio, Ontario
SL3-118-2186	Detroit, Mich., Ohio
SL3-118-2187	Detroit, Mich., Ohio
SL3-118-2199	Detroit, Mich., Ohio

TABLE A-5

NASA SKYLAB AIRCRAFT UNDERFLIGHTS

MISSION 238: East Liberty to Dayton * 3 Flight Lines, good

Date	Roll	Type	Filter	Frames
6/13/73	74	Color Positive	2A (Haze)	92-179
6/15/73	59	Color IR	510	62-149
6/13-15/73	61	B&W HASS	58 (Green)	97-187
6/15/73	62	B&W HASS		97-189

MISSION 253: Cleveland 3 Flight Lines, good

Date	Roll	Type	Filter	Frames
8/5-6/73	4	Color Positive	AV	41-131
8/5-6/73	5	Color IR	510 MM	40-130
8/5-6/73	6	KA 62 B&W	57 (Green)	4-93
8/5-6/73	7	KA 62 B&W	25A (Red)	4-101
8/5-6/73	8	KA 62 B&W	89B (IR)	3-99

MISSION 247: Buckeye Lake Thru Columbus 3 Flight Lines, good

Date	Roll	Type	Filter	Frames
8/10-16/73	60	Color IR	510 MM	41-108
8/12-16/73	112	Color IR	510 MM	116-185
8/16-24/73	64	B&W HASS	58 (Green)	2-70
8/16/73	66	B&W HASS	89 (IR)	3-70
8/24-29/73	62	Color Positive	AV & 2A (Haze)	59-126
8/24/73	64	B&W HASS	25A (Red)	2-70
8/28/73	113	Color Positive	2A (Haze)	66-135
8/28-29/73	115	B&W HASS	25A (Red)	1-70
8/28-29/73	116	B&W HASS	57 (Green)	14-83
8/28-29/73	117	B&W HASS	89B (IR)	1-70

MISSION 258: Buckeye Lake Thru Columbus 3 Flight Lines, Excellent

Date	Roll	Type	Filter	Frames
1/25/74	125	Color Positive	CL AV (Haze)	1-74
1/25/74	126	Color IR	15 (Yellow)	1-76
1/25/74	127	B&W HASS	58 (Green)	1-74
1/25/74	128	B&W HASS	25-A (Red)	1-74
1/25/74	129	B&W HASS	89-B (IR)	1-74

* Incorrect acquisition - should have been Cleveland SL-2 underflight.